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AUTOMOTIVE INDUSTRIES
APRIL 1990
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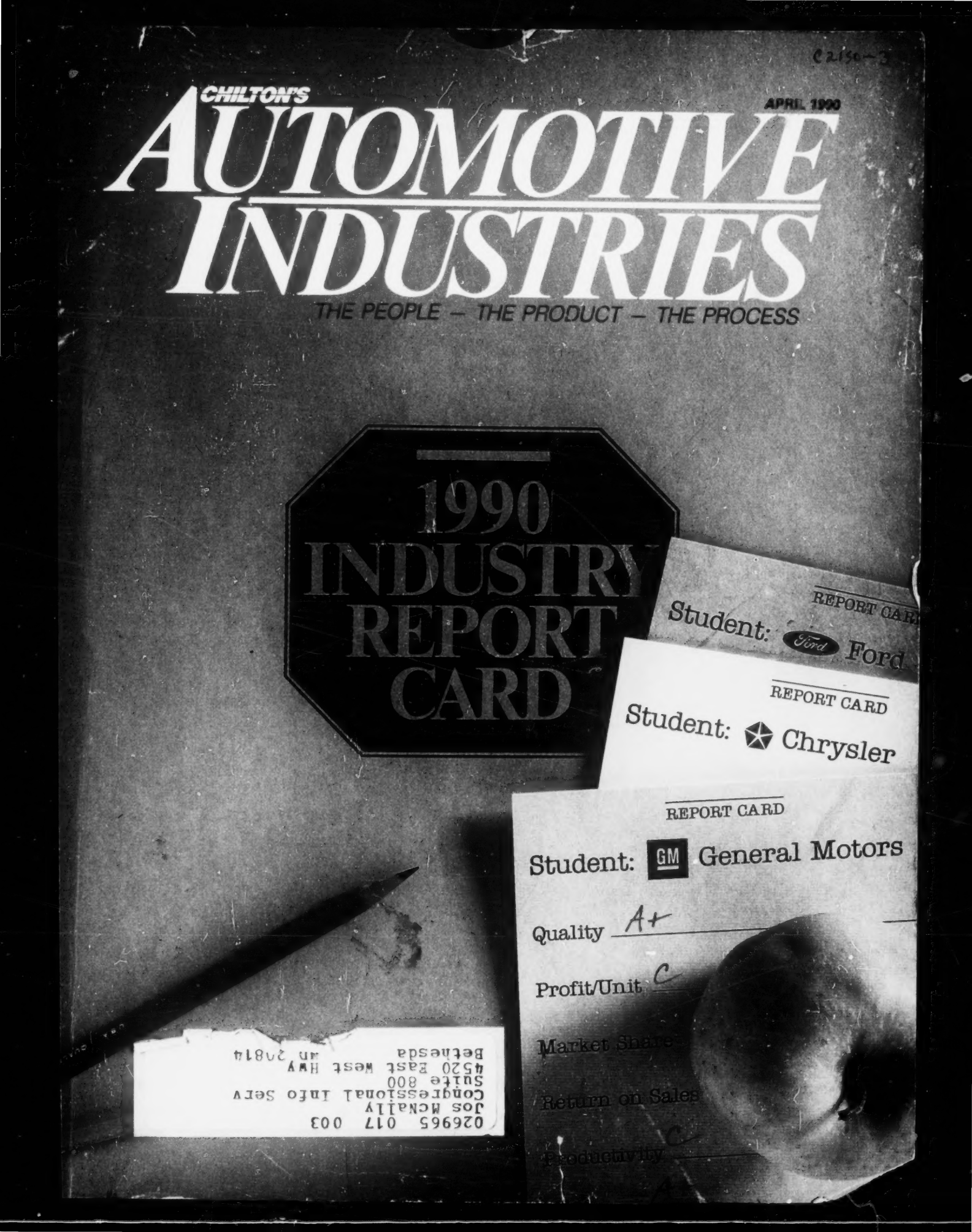
1990 INDUSTRY REPORT CARD



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GM's Impact marries performance and electricity in one practical package. Page 36.

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1990 INDUSTRY REPORT CARD

Poorer, but more efficient.

by JOHN McELROY

The boom times are over. For the last seven years, the American auto industry enjoyed one of its strongest growth rates on record. But now, with higher interest rates, substantial overcapacity, and a saturated market, the brutal laws of capitalism are separating the well-run automakers from those that have been just plain lucky.

In 1989, the US market fell by 1.23 million units (7.8%). That's quite a drop, but it still represents the eighth best year in the history of the industry.

While the domestic automakers found it tough going, the imports fared well. Total import car and truck sales reached 3.86 million units, (26.5% of the market), up from 3.78 million units (23.9%) in 1988.

But the Europeans – except Volvo – ran into trouble. Their 1989 sales totaled 479,000 units (3.3%), down from 569,000 (3.9%) in 1988. The Koreans lost a lot, too. Including captive imports, their sales fell to 297,000 units (2.0%), down from 397,000 (2.5%) in 1988. Obviously, it was the Japanese who made the big gains, though Mazda and Subaru lost both sales and share.

But so much for the imports. To help you keep track of how the Big Three fared in 1989, each automaker has been graded according to how it performed in six different categories over a period of time. Each grade is given according to the company's own trendlines. In other words, we don't compare one company to another. We compare each company against its past efforts, and then sum it up with an overall grade.

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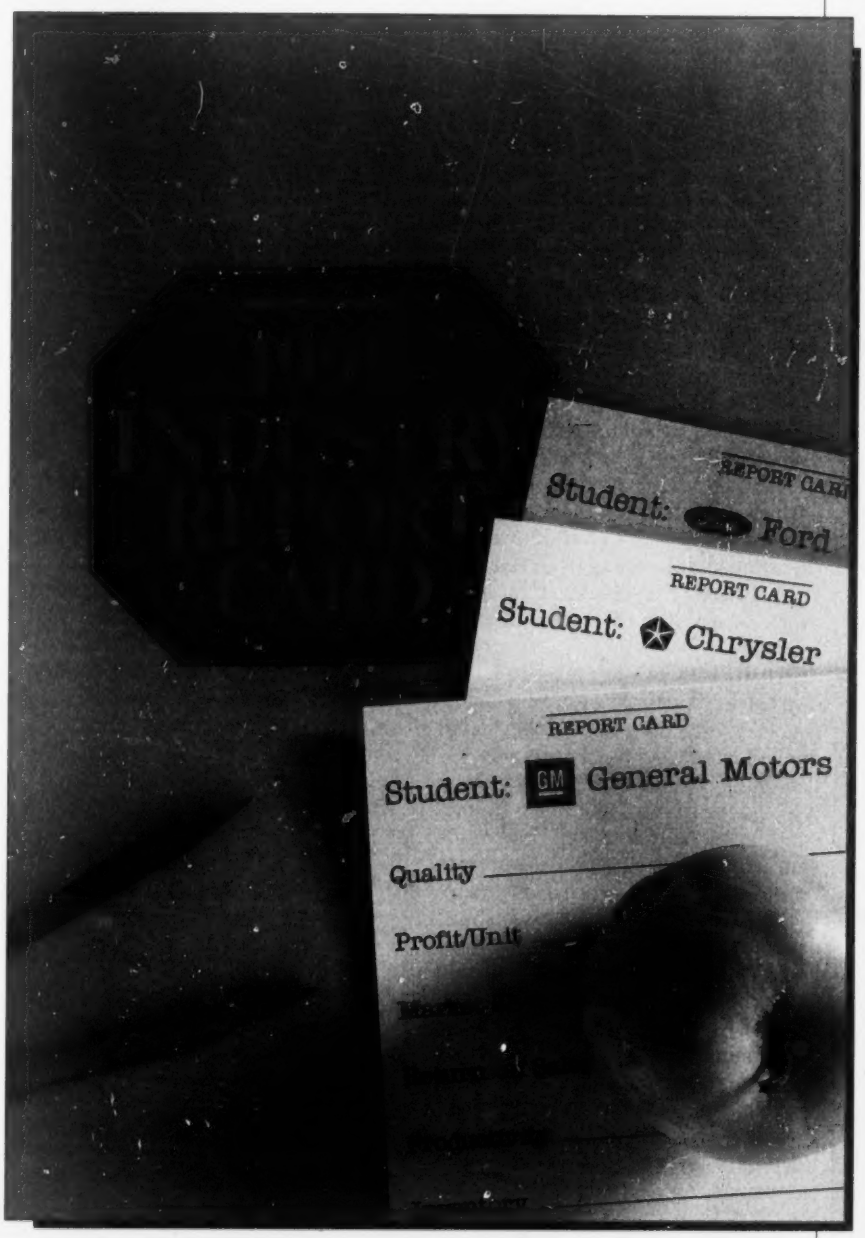


INDUSTRY REPORT CARD

At Ford, new products equal more efficiency.

FORD MOTOR COMPANY

Quality: Ford has had its ups and downs in the last three years. But the latest report, which is based on J.D. Power's Initial Quality Survey, shows the company is building cars with far fewer defects per 100 vehicles.

We've noted before that Ford's slowdown in the Quality category was probably due to the high level of overtime the company was using in the last few years. In 1989 the company reduced its overtime, and its quality improved dramatically.

Profit/Unit: It's surprising to see how far Ford's profit per unit dropped last year. Obviously, a lot of this had to do with the fact that the company relied on heavy marketing costs to keep its vehicles selling well in the American market. But even the company's vaunted overseas operations were not immune from the downturn. Overseas profits were off 3% at $2.1 billion, dragged down almost entirely by Ford of Europe – despite record vehicle sales there. This was due in part to Ford of Europe's higher new-product development costs on the Fiesta and CDW-27 (Tempo, Sierra), and labor problems in England.

Market Share: This is an area where Ford did very well. Even though the company's sales actually fell, they fell a lot less than the rest of the market did, which allowed it to increase market share. Not only are Ford's cars and trucks well received by American consumers, the company stepped in and applied incentives to make sure the products kept moving. For all the talk of the short-term outlook of American automakers (much of it deserved), they certainly do keep a keen eye on their share. And that's a sign of long-term thinking.

Having said that, however, the best selling car in the United States last year wasn't the Escort or the Taurus, it was the – gulp – Honda Accord! And what Honda gets, it doesn't give up easily. Even so, we expect a big push from the new Escort to reclaim the top spot.

Return On Sales: From a financial standpoint, Ford slipped a lot in 1989. Automotive profits were down $1.4 billion, and almost all of that dropoff came from the US. About $424 million of the US loss came from selling off Rouge Steel at below book value, while the rest is accounted for by a decline in sales, higher marketing costs (rebates), and higher new-product development costs.

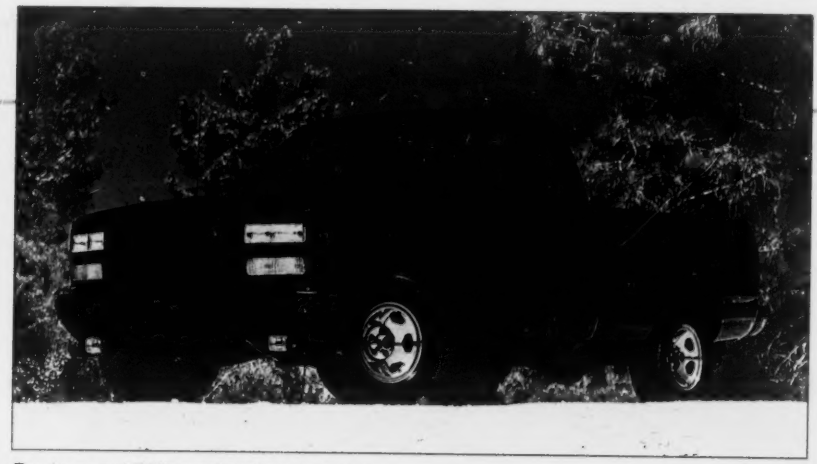
Simply put, the company's problems stem from one simple fact: Total automotive sales increased only $686 million dollars, while the cost of sales rose by nearly $2.4 billion. It seems safe to predict that Ford chairman Red Poling will attack these costs with a vengeance.

Productivity: Even though it built fewer vehicles worldwide last year, Ford managed to increase its productivity. That performance is all the more impressive considering that Ford also cut way back on overtime in its North American facilities. This shows that the company is maintaining its goal of improving productivity with each new vehicle it introduces – a process that starts in the earliest stages of design.

Inventory Turns: Despite a downturn in sales, Ford was able to improve its inventory turns. This is impressive, because a sales downturn makes it more difficult to balance production schedules, which in turn tends to drive up inventory levels. By improving its turns in a down market, Ford shows that it is managing its manufacturing operations well – a fact corroborated by its improvement in quality and productivity.

FORD MOTOR CO.

CATEGORY	1973	1978	1987	1988	1989	GRADE
Quality (defects/100)	--	--	156	169	143	B
Profit/Unit	$260	$360	$1023	$1014	$663	D
Market Share	29.8%	26.5%	23.1	23.7%	24.6%	A
Return On Sales	3.9%	3.7%	6.4	5.7%	3.9%	D–
Productivity (cars/man/yr.)	13.7	13.8	18.7	19.9	20.9	A
Inventory Turns	5.3	6.5	15.6	17.3	18.0	A
				OVERALL GRADE:		B–



Trucks saved GM's market share last year.

GENERAL MOTORS CORP.

Quality: This is one area where GM is coming on strong. But it's Buick, Olds and Cadillac – in that order – which deserve all the credit. Buick has been especially impressive. It now ranks seventh overall in the US marketplace and only has one (1) more defect per 100 cars than does Acura. Olds is tied with Lincoln, and Cadillac is well ahead of BMW.

At the other end of the spectrum are Chevrolet and Pontiac, which don't even make the top 20 – a problem that should be setting off "Red Alert" warnings at C-P-C.

B-O-C will be introducing a slew of new cars in the next three years, and we expect the group's quality ratings will go higher still. The reason is that these vehicles will be designed with far more ease-of-manufacturing than current models.

Profit/Unit: GM slipped in this area, but not nearly as badly as might have been expected, and certainly not as badly as Ford. This is due to the company's extremely profitable overseas operations, particularly those in Europe, which netted $1.8 billion in profits. In fact, GM earned $1143 per unit sold in Europe.

It was largely the high cost of marketing (meaning rebates) in North America that dragged down GM's overall profitability. This poses a question for the future: What happens to GM's profitability if EC92 turns into a price war and rebates become a widespread marketing tool in Europe, too?

Market Share: Not many people seem to have caught on to the fact that GM is gaining US market share. But it's GM's truck sales that are saving the company. GM's truck sales fell only 1% last year, compared to 2.8% for the total US truck market.

On the passenger car side of the ledger, GM sales dropped by 385,000 units, which was equal to one full market share point. One would think that GM's positive quality rating would have prevented such a drop off. Since it didn't, this strongly suggests that GM continued to do an ineffective job of marketing its products – except for Cadillac and Buick, which increased their penetration.

Return On Sales: GM was pleased to announce that it had outearned Ford for the first time in several years. But that was mainly because Ford had bigger financial problems than GM. The Number One automaker not only suffered an overall drop in profitability, it suffered a drop in overall efficiency as reflected in its lower return on sales.

One has to wonder how much credence can be placed in GM's much vaunted Action Plan, which supposedly has cut costs by $11.5 billion since 1987. GM claims that $3 billion of those savings were achieved last year alone. On top of that, its overall 1989 sales increased by more than $3 billion. This would suggest a $6 billion turnaround. Yet, the company's profits actually fell. It seems that the Action Plan must be made up of cost avoidances, rather than actual improvements in efficiency.

Productivity: GM is going nowhere in this category, as the total historical trendline demonstrates all too clearly. In fact, last year GM fell behind, while Ford and Chrysler surged ahead. This shows that GM is still operating with too much overcapacity – especially in North America. Unfortunately, this probably foretells a big battle this fall between GM and the UAW as the company strives to streamline its operations and the union fights to save jobs.

Inventory Turns: This is a category in which GM scored as impressively as it did in Quality. And there is a direct correlation between the two. With less inventory lying around, quality defects come to the surface more quickly.

Though the Productivity category shows that the company wasn't able to build more vehicles with fewer people, at least the Inventory Turns category shows that GM used its manufacturing facilities more efficiently. It did an outstanding job of building what was needed, when it was needed and in the needed quantities.

Continued on p. 32

GENERAL MOTORS CORP.

CATEGORY	1973	1978	1987	1988	1989	GRADE
Quality *(defects/100)*	--	--	176	165	158	A+
Profit/Unit	$490	$684	$435	$692	$645	C
Market Share	51.5%	47.3%	34.7	34.9%	35.0%	B+
Return On Sales	6.7%	5.5%	3.5%	4.4%	3.8%	C
Productivity *(cars/man/yr.)*	11.4	12.1	11.3	12.9	12.6	C
Inventory Turns	5.4	6.7	18.0	18.8	20.0	A+
					OVERALL GRADE:	B–

INDUSTRY REPORT CARD

Chrysler's rebates hurt profits.

CHRYSLER CORP.

Quality: Chrysler's quality rating has been sort of up and down in the last three years. In 1989 the company made a tremendous improvement, but it still lags behind GM and Ford.

Unfortunately, Chrysler is in something of a "catch-22" situation. Since it only has one platform, it can easily make quality improvements across the board. But at the same time, it has to wait for a new platform before it can incorporate new designs and technology that can further boost quality—and that means every carline suffers in the interim. In this regard, the company will be held back until the new LH platform arrives for the 1993 model year. Nonetheless, as the 1989 quality category demonstrates, Chrysler has been able to cut down on the number of defects per 100 cars it builds.

Profit/Unit: Obviously, you can't become The Rebate Company and expect your profitability to remain high. Not only did Chrysler continue its aggressive rebate program throughout 1989, by the end of the year the company was rebating its massively profitable minivans and Jeeps. That hurt the bottom line. And will consumers expect anything less than a rebate on the minivans and Jeeps again?

Market Share: This is a category in which Chrysler could be on a long, slippery downhill slide. Despite the fact that the company unleashed a barrage of marketing gimmicks, it was not able to hold onto its share of the market.

Like GM, it was Chrysler's truck operations that prevented a bad situation from getting worse. The company's car sales were off 171,600 units (14.4%), while trucks fell by 32,400 units (3.1%).

Return On Sales: This is another area where Chrysler fell badly. On the one hand, the company was bouyed by selling 75 million shares in Mitsubishi Motors Corporation, which boosted its bottom line by $300 million. On the other hand, by writing down several operations, with the unemployment benefits and pensions costs such actions bring, the bottom line was reduced by $577 million.

Since Chrysler chairman Lee Iacocca has stated the company needs to close more operations, this doesn't bode well for next year. But *on the other hand*, Chrysler sold Gulfstream Aerospace in February 1990 for a $183 million profit. Its Electrospace Systems and Chrysler Technologies Airborne Systems are on the auction block, too.

Productivity: Chrysler's manufacturing operations are turning into a competitive asset for the company. Last year, it turned in a solid 8% improvement, despite the fact that sales went down.

And the year before, when sales were up, Chrysler boosted its productivity by 11%. This rate of improvement is better than what Ford achieved in the last two years, and shows that Chrysler is starting to hit its stride in manufacturing efficiency.

Inventory Turns: This is a category in which Chrysler turned in a spectacular performance. By carefully controlling its manufacturing operations, it was able to eliminate a lot of waste in the system. And this confirms that the company's good showing in the Quality and Productivity categories was no fluke.

If Chrysler can keep up this rate of improvement, by the middle of the decade it could be up there with the best of the Japanese in this category. AT

CHRYSLER CORP.

CATEGORY	1973	1978	1987	1988	1989	GRADE
Quality (defects/100)	--	--	178	202	169	B
Profit/Unit	$127	($129)	$853	$649	$249	D–
Market Share	15.6%	11.2%	12.3%	13.9%	13.7%	C–
Return On Sales	2.1%	(1.5%)	4.5%	3.0%	1.0%	F
Productivity (cars/man/yr.)	13.0	13.1	16.2	18.0	19.5	A
Inventory Turns	5.6	6.3	16.8	21.6	26.3	A+
( ) = negative number				OVERALL GRADE:		C+

PRODUCTIVITY VS. PROFIT SHARING

How to get more efficient – and why the union is worried.

by BRUCE BEIER
and MARY GEARHART

This article, based on findings from *The Harbour Report*, analyzes labor productivity and its relationship to profit sharing. But why focus on labor, in this age of automation, when most people believe that labor is only a fraction of the cost of goods?

Well, that's not exactly right. While it is true that direct labor is estimated to be about 10% of total costs, the total cost of all labor – that is wages and benefits for all direct, indirect, and salary manpower – is estimated to be as high as 25%.

Over the past 10 years, each of the Big Three has taken different approaches to improving operations, which has had various effects on labor productivity. The chart (below left) illustrates Big Three labor productivity improvements in four key areas: assembly, stamping, engines and transmissions.

As you can see, Ford has made substantial improvements in labor productivity – much more so than Chrysler or GM. But what does this mean? Just because they've improved more, it doesn't mean they're better, does it? Maybe they were less productive to begin with! Let's use vehicle assembly to see if this is the case.

Labor Productivity Improvement 1979 to 1989

	Assembly	Stamping	Engines	Trans.
Chrysler	19%	30%	9%	N.A.
Ford	31%	45%	43%	45%
GM	5%	14%	-13%	-2%

Source: *The Harbour Report: A Decade Later*

Vehicle Assembly Labor Productivity (Workers Per Unit Per Day*)

	1979	1989	Improvement
Chrysler	5.63	4.58	19%
Ford	4.71	3.25	31%
GM	5.12	4.88	5%

*Workers per unit per day calculated using daily production & total assembly employees for the company (hourly & salary).

Source: *The Harbour Report: A Decade Later*

Obviously, Ford not only made sub-

Continued on p. 55

Asia Series

On your day off, you'll find Seoul has many interesting features.

Seoul is known as a great place for bargains, and Itaewon is one of the best places to find them. Seoul also has many other attractions. Walking tours and trips outside the city provide a look at Korean culture. So, if you're there on business, take time to see Seoul at more than face value.

Zone out.

At the 38th Parallel lies the Demilitarized Zone (DMZ). Once there, you can visit Panmunjom, site of the armistice that ended the Korean War. Don't miss the 240-foot-deep tunnel, cut into bedrock, that heads toward Seoul. For a full-day tour phone the Korea Travel Bureau (tel. 2-585-1191) two days before you want to go.

Visit the folks.

The Korean Folk Village, just outside Seoul, is a living museum in which potters, weavers, millers, blacksmiths and other craftsmen recreate the lifestyles of times past. The major hotels have information about day trips.

Standing tall.

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NORTHWEST AIRLINES

Impact of Labor Productivity on Vehicle Cost 1989

Process	Ford	Chrysler	GM
Vehicle Assembly Labor Cost/Vehicle	$780	$1121	$1171
Body Stamping Labor Cost/Car Set	$259	$336	$384
Engines Labor Cost/Engine	$175	$245	$233
Transmissions Labor Cost/Transmission	$173	$163	$228
Ttl. Labor Cost/Vehicle (excluding components)	$1387	$1865	$2016
Cost Over Base/Vehicle	N.A.	$478	$629
Annual Penalty (Billions)	N.A.	$1.6	$3.65

Based on a labor rate of $30/hour

Source: *The Harbour Report: A Decade Later*

PRODUCTIVITY

Continued from p. 53

stantial improvements, it is also significantly more productive than Chrysler or General Motors.

Well, so what? What does this have to do with profit sharing? We're getting to that. But first you need to know what effect labor productivity has on costs. (And boy, does labor productivity affect costs!) (See chart above.)

It doesn't take a rocket scientist to figure out that these cost penalties to Chrysler and General Motors translate directly into lost company profits. And what do lost company profits translate into? You guessed it: low or no employee profit sharing!

Profit Sharing at The Big Three

	GM	Ford	Chrysler
1984	$643	$400	$0
1985	$543	$2000	$0
1986	$347	$1200	$0
1987	$0	$2100	$0*
1988	$0	$3000	$0*
1989	$254	$2800	$720
1990	$50	$1025	$0
TOTAL	$1837	$13,255	$720

Paid in year indicated based on corporate profits from the previous year

*Contractual payouts, not tied to profits, were $500 for '87 and '88

Source: *The Detroit Free Press*

The chart (below left) shows profit sharing payouts for each of the Big Three since 1984, when they were introduced into the national agreements. Chrysler did not have a profit-sharing agreement until 1987, when it agreed to employee bonuses of $500 for 1987 and 1988. The GM payout for 1990 is a contractual minimum.

If you refer back to the chart showing productivity improvements for the Big Three, you can see that there is definitely a correlation between labor productivity and profit sharing.

Now that we've established the relationship between labor productivity and profit sharing, maybe we should back up a little and explain exactly what we mean by labor productivity. What makes one company more productive than another?

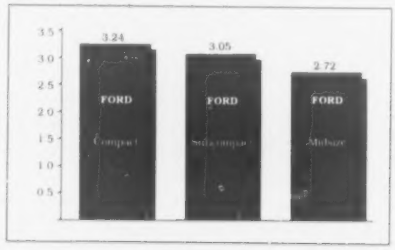
Productivity is, by definition, what you get out of a system (output) divided by what you put into a system (input). In this case, the output is whatever is produced (cars, engines, etc.). The input is everything it takes to make the output (materials, labor, energy, etc.). Specifically, labor productivity is just what it sounds like – the amount of units of output divided by the number of people used to produce them. In our report, we have inverted the ratio of units per worker to obtain the number of workers it takes to produce one unit of output.

To improve productivity, one of three things must happen. You must increase output with the same number of employees, reduce the number of employees with the same amount of output, or increase output and reduce the number of employees. But increasing labor productivity is not merely the result of cranking up the line speed (although there are plenty of managers who have tried to use this method).

The difference in productivity between plants and companies, contrary to popular belief, is not because workers goof off in one plant, while workers in another plant rush around at a breakneck pace to keep up with the production line. It may be true that some people just work "harder" than others, but this is not the main reason for productivity differences from plant to plant. There are many other factors that cause these differences.

Before we discuss these factors, we need to clarify some common misconceptions – two to be specific.

The first one has to do with the size of the car. Many people believe that if you are comparing the productivity of two plants, the plant that makes the larger car will automatically be less productive, purely because of the car's size. But our research shows that this is not the case. While it is true that vehicle content affects assembly productivity, vehicle size alone does not account for the differences in productivity. The following chart, showing workers per car and car size, illustrates this point.



Another common misconception is that the sourcing differences between companies and plants account for a significant portion of the productivity difference. While it is true that sourcing affects productivity levels, the question is, "By how much?"

We examined some typical Big Three assembly plants to try to determine the answer to that question. As the

Continued on p. 56

Typical Assembly Plant Sourcing Differences

	GM Doraville (Olds Cutlass)	Ford Atlanta (Taurus/Sable)	Chrysler Newark (Acclaim/Spirit)
Bumper Assembly	YES	NO	YES
Seat Buildup	YES	YES	NO
Fixture Const/Repair	YES	NO	YES
Rail Car Loading	NO	YES	NO

Source: *Harbour and Associates, Inc.*

Typical Assembly Plant Labor Productivity Adjusted for Sourcing

Plant	Actual Workers/Unit	Adjusted Workers/Unit
Chrysler Newark	4.36	4.65
Ford Atlanta	2.72	2.77
GM Doraville	5.50	5.55

Source: *Harbour and Associates, Inc.*

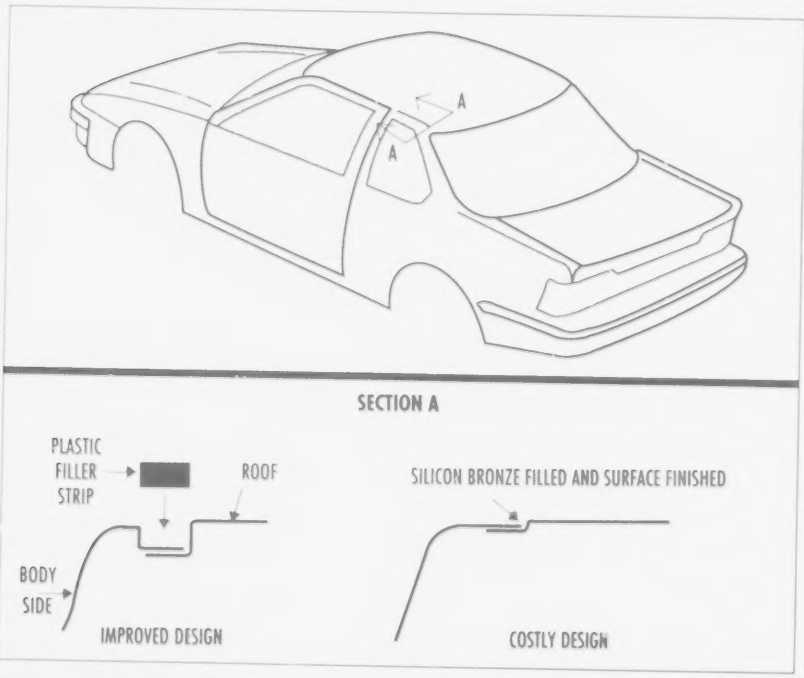
PRODUCTIVITY

Continued from p. 55

two charts above illustrate, not only were there few differences in the level of sourcing, the difference between plants in terms of workers per unit was the same or larger after adjustments for sourcing.

Now that the misconceptions have been clarified, let's talk about the factors that make one company more productive than another. As we said, there are several. One of them is design for manufacturing and assembly (*DFMA*, see March '90 *AI*, p. 34).

The illustration below shows an improvement in the roof to body side joint design. The design of the lap joint allows extremely tight tolerances to be maintained on critical body dimensions regardless of variations in the body stampings. By replacing the operations of silicon bronze and body finishing with the plastic filler strip, approximately 30 fewer workers are needed. By itself, this design change does not account for huge productivity differences, but imagine what hundreds of similar design changes will do.



Another area which affects labor productivity is worker utilization. You may argue that we said the difference wasn't because people in one plant work harder than people in another, so how can we now say that a major factor is worker utilization?

There are two parts to the definition of worker utilization. Part one is the number of minutes per hour a person works. Part two is the amount of the time spent working which is value added. Minutes worked per hour is affected by process engineering and line balancing. If only $^2/_3$ of the cars coming down the line need the parts being installed, then $^1/_3$ of the time is being wasted. Similarly, value added time is also affected by process engineering. If of the $^2/_3$ of an hour an employee is working, he spends half of that time walking or looking for tools, then he's only installing parts (adding value) a net of $^1/_3$ of the time.

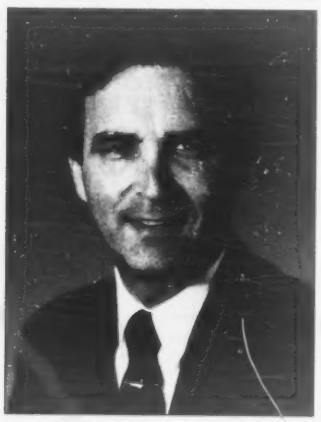
Workplace engineering is another factor affecting productivity that is also related to worker utilization. This includes plant and workstation layout, containerization suited to specific parts and tasks, elimination of off-line subassembly operations, as well as other techniques.

Quality is yet another area affecting productivity. Good quality, built into a product the first time, requires significantly fewer people than producing parts that require 100% inspection, sorting and repair work. Many companies have already proven that quality and productivity are complimentary rather than contrary.

So, what is the gist of all this talk about productivity? Improvements in productivity have a direct impact on how many jobs are needed. While many of the productivity-improvement factors cited here are management's responsibility to address, there is no question that the union leadership will have to be involved.

Eventually the union will have to decide whether or not to swallow the politically bitter pill of reduced membership. If it decides against this, then it runs the risk of sacrificing both profit sharing and job security. AI

Ag Equipment Sales Ripen



JOHN STARK is editor and publisher of Stark's Off-Highway Ledger in Chicago, IL.

Farm machinery producers are anticipating a major rebound in farm vehicle sales this year.

The North American farm machinery business is in the midst of a rebound, the extent of which will be gauged at the end of the spring planting/selling season.

Farm acreage plantings are on the rise. Farm asset values are climbing. Debt loads are falling, and net cash income is on the mend as prices for harvested crops continue to improve.

For US and Canadian manufacturers of farm tractors and self-propelled combines, assembly plant output has risen for nearly 24 straight months. It follows an end to steep vehicle price discounting and widespread depletion of good used tractor and combine stocks on dealer lots.

In 1989, retail demand for all vehicles ended nine consecutive years of decline, as unit turnover rose by 2%.

More significantly, producer use of existing farm assembly plant capacity surged to a seven-year high throughout North America in 1989, as tractor and combine assembly rebounded for the third straight year.

Farm machinery manufacturers produced 51,630 units in 1989, a 22% increase from 42,385 vehicles in 1988. It was the highest level of annual output since 1984, when 71,390 units were built.

High-horsepower tractor and combine sales in the US and Canada rose by 34% in 1989, to 39,895 from 29,715 units in 1988. Yet, vehicle assembly outstripped annual sales, a clear sign that manufacturers continued to rebuild dealer inventories for the second straight year.

It indicates that farm machinery producers are rebuilding stocks at dealer outlets, in anticipation of a major rebound in farm vehicle sales this year.

John Deere expanded its position as the leading volume-maker of tractors and combines in 1989. Although its share of unit assembly slipped to 50.5% in 1989 from 52.5% in 1988, vehicle volume expanded to its highest level since 1983 – a 17% rise to over 1988.

J.I. Case ranked second at 32% versus 30.5% in 1988. It was Case's highest level of production since 1985. Ford New Holland was third at 8%, unchanged from 1988. White-New Idea Farm Equipment built the fourth highest volume of vehicles, with 6% of industrywide unit output, up from 4.5% in 1988. Deutz-Allis was fifth and Caterpillar, a marker of large four-wheel-drive tractors, was sixth. Massey Combines fell into receivership and was liquidated.

A closer look at overall industrywide production activity shows that farm tractor assembly increased by 17% in 1989, to 39,115 from 33,395 vehicles in the previous year. Combine production rose by 39% to 12,515 from 8990 as manufacturers raised daily assembly schedules in the wake of a major market upturn during late 1989.

In 1990, North American sales of tractors and combines are seen advancing by another 7%. It could lead to an additional 25% rise in unit vehicle output – to 64,500 machines.

While 1990 vehicle assembly is still seen below the 1984 level of 71,390, the longer-term trend points toward a more substantial recovery in 1991 – capping a five-year rebound in the current business cycle.■

North American Farm Machinery Production, 1983-1989

	1989	1988	1987	1986	1985	1984	1983
Deere	26,045	22,230	15,630	5260	13,250	20,415	28,480
Case	16,515	12,945	9985	9200	17,125	17,315	18,010
Ford	4115	3455	5590	10,430	14,285	20,775	21,720
White	3000	1830	2575	1475	345	2335	1250
Deutz	1370	1460	1645	1240	3035	8500	7815
Caterpillar	585	465	385	—	—	—	—
Massey	—	—	1390	750	1675	2050	1620
Total	51,630	42,385	37,140	28,355	49,715	71,390	78,895

Note: Acquired and merged farm machinery companies' results combined to display true pattern of year-to-year change in farm tractor and self-propelled combine assembly activity in the US and Canada.

TOHI
TRUCK & OFF-HIGHWAY INDUSTRIES

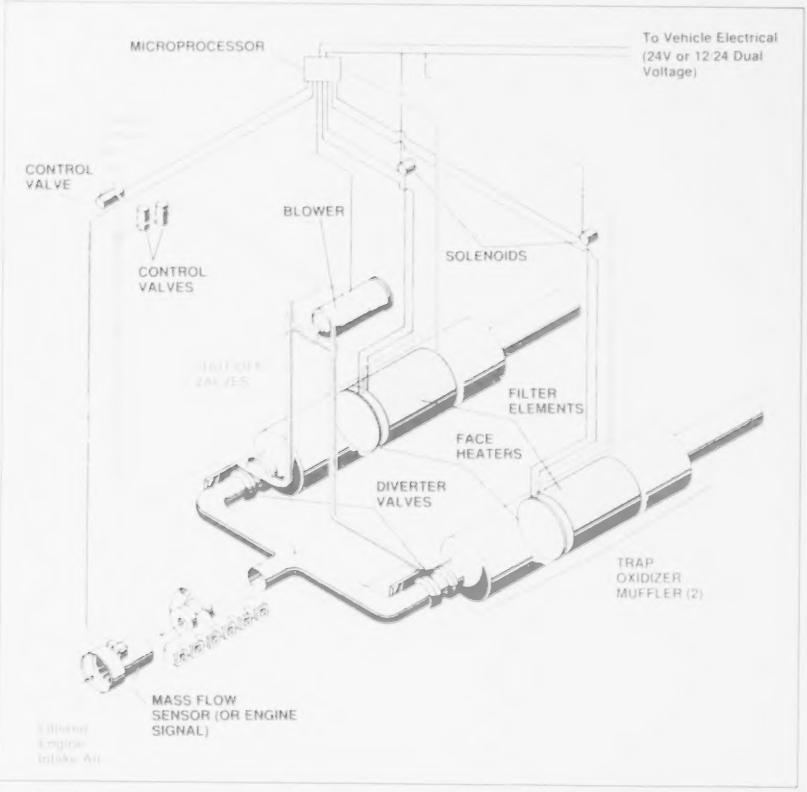
THE 'WALL' COMES DOWN

How are America's dieselmakers meeting the 1991 and 1994 EPA regs?

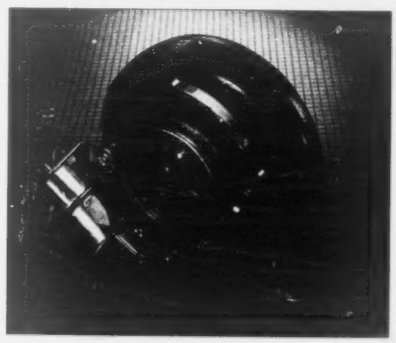
by LINDSAY BROOKE

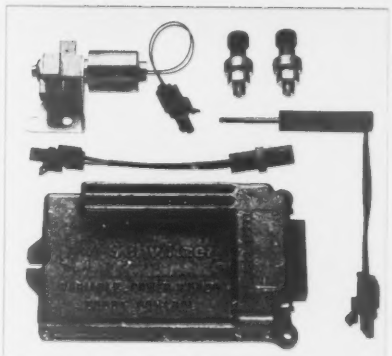
Just four years ago, many US diesel engine makers saw the EPA's increasingly stringent emissions regs as a 'wall' that couldn't be scaled. At that time, some felt the upcoming 1988 particulate (PM) standard of .6 grams per horsepower hour (g/hp-r) might even spell the end of the diesel engine. Technology, lots of dyno hours and thousands of test fleet miles proved them wrong.

The 1991 NOx and PM regs have upped the ante again—and the ultra-clean '94 PM standards (see chart) have many diesel engineers worried. Some current engines may be discontinued by '94, while others will need extensive modification to meet the new regs.



Donaldson Co.'s particulate trap is being tested on 400 Detroit Diesel-powered New York buses. In this system, called bypass regeneration, core is heated (burning soot inside), while exhaust flow is bypassed either to muffler or to another trap system. Donaldson is experimenting with both electricity and diesel fuel to heat the burner.





Variable-geometry turbochargers may be common on truck diesels by '94, yielding lower emissions through improved boost control over the rpm range and better fuel economy. Mack has tried new Schwitzer VPT (Variable Power Turbo). Turbo vane control is by Schwitzer ECU. Garrett's new VNT (not shown) is in production on Nissan heavy diesels.

How are America's major dieselmakers facing these challenges? Here's what's coming in '91, with an update on the industry's progress towards 1994.

1994: WHAT'S COMING?

Low Sulfur Fuel

Diesel manufacturers have lobbied the EPA hard for cleaner diesel fuel containing a maximum sulfur content of .05%. Current diesel fuel sulfur levels are near .3%, and since roughly 33% of PM emissions are byproducts of fuel sulfur, this will be an important step.

Although low-sulfur fuel will not allow engines to reach the .1 g hp-r PM level, it's crucial to aftertreatment systems. Catalytic converters depend on clean fuels; without them, sulfates (solids) in the exhaust are formed which can't be oxydized in the catalyst.

The diesel industry would like the new fuels mandated and available from all US refineries by 1991. It's likely that will happen by '93 instead, even though the EPA intends to allow '91 diesel emission certifications using the new fuels. Currently, the EPA is talking about granting exemptions to small refiners who have complained about the plan's cost and timetable. Some chief engineers at the diesel companies say this is just another way for the oil industry to duck the issue.

Aftertreatment

Whether dieselmakers jump on the exhaust aftertreatment bandwagon *as an industry* is the $64,000 question. Generally, engineers are encouraged by the progress they're making with this technology. It's now on test by all the players, but nobody's talking about which type of system they're favoring – regenerative soot traps with or without catalytics (some using expensive noble metals), electrically-heated types, or those heated using diesel fuel are the leading candidates.

Concerns continue about clogging

Continued on p. T-8

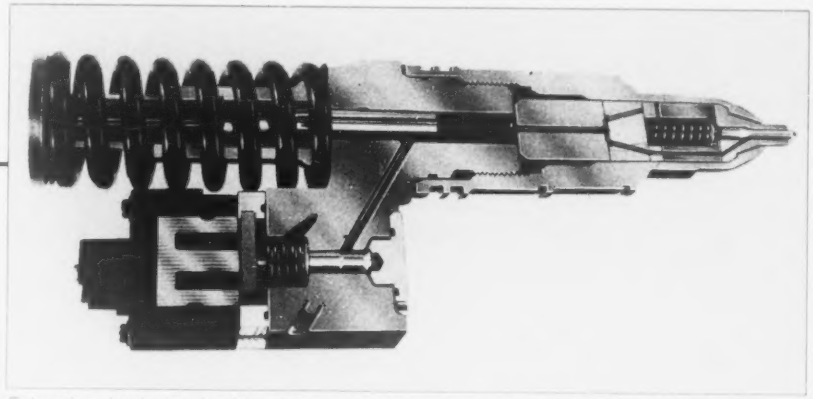
EPA Medium- And Heavy-Duty Diesel Emissions Regs (g/hp-r)

	CO	HC	NOx	PM
1990	15.5	1.3	6.0	.60
1991	15.5	1.3	5.0	.25
1994	15.5	1.3	5.0	.10

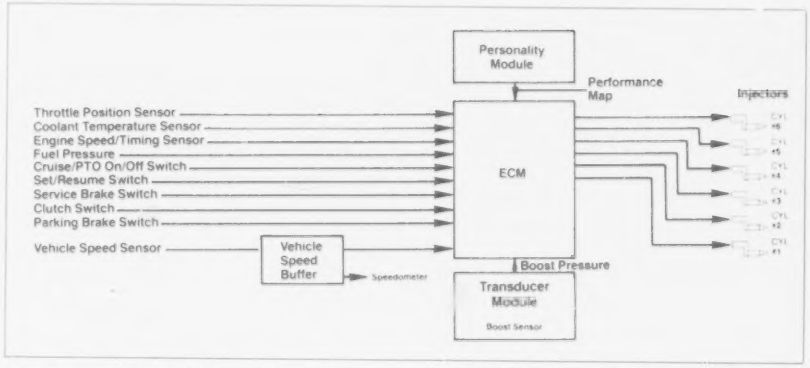
DIESEL EMISSIONS 1991:

Who's	Doing What?
EPA	Allowing each dieselmaker emissions averaging, emissions credit trading and credit banking, and payment of non-conformance penalties. This way, newer, cleaner engines can help older products survive – at least until 1994
CATERPILLAR	Raising injection, cylinder pressures Low-inertia turbos on 3176, 3406 Tweaking injection nozzles, turbos and electronic fuel maps on PEEC Low-crevice volume (LCV) pistons on 3406 Raising horsepower in some ratings
CUMMINS	Raising injection pressures Adding new PCI electronically-controlled unit injector (mid-'90) Improving piston, ring technology Offering CNG or methanol-fueled L10 Raising horsepower in some ratings
DETROIT DIESEL	Raising injection pressures on Series 60 and two-strokes Higher top-ring pistons on Series 60 Tweaking cam profiles, valve event, turbos, compression ratios Electronic engine controls (DDEC) standard on 71- and 92-series two-strokes Offering methanol-fueled 6-71 and 6V-92 Raising horsepower in some ratings
FORD	Raising injection pressures, comp. ratios Tweaking injection timing, fuel delivery profiles, rated rpm New pistons with re-entrant chambers No electronic controls for '91 Adding new 215-hp/2000 rpm rating
MACK	Adding electronic engine management (VMAC) to E7 range, mid-'90 Raising injection pressures Tweaking injector nozzles Higher top-ring pistons Possible air-to-air intercooling and variable-geometry turbo Adding highest E7 horsepower rating: 425-hp
NAVISTAR	Raising injection pressures, other changes per progress on 1994 'smokeless' engine

H-D DIESEL EMISSIONS



Entire diesel industry should embrace electronic unit injectors by '94. Detroit Diesel's (shown) is made by Penske-owned Diesel Technology Corp.; is used on both Series 60 and two-stroke range.



Fully-integrated electronic controls, injectors help Cat 3176 meet '91 spec. Cat is basing its methanol program around 3406B series.

with soot, wear metals and compounds that can't be oxydized. Increased backpressure, and its effect on engine performance, also presents a challenge.

Navistar is using a flow-through catalyst system on its 'Smokeless 94' diesel introduced late last summer. With the engine, based on the company's DT466 (see October '89 T&OHI, p. T-6), Navistar claims it can beat the '94 PM standards. Navistar has yet to prove the converters' total durability at the legally required 150,000 mile mark. And some diesel engineers claim that's not enough anyway.

"Navistar's done a great PR job on that engine," says Dave Merrion, senior VP, engineering, at Detroit Diesel. "Manufacturers need to certify their engines for the useful life—and for heavy-duty diesels, that's 290,000 miles. Some of the technology's there now, and some of it isn't."

How To Aftercool?

There is some speculation that the '94 diesel regs will spell the end of non-air-to-air aftercooling systems. Aftercooling affects the conversion efficiency of aftertreatment devices. Word from within the supplier community has Cummins opting for air-to-air over its current air-to-water system. One reason for such a change, if it happens, might be because with the change in the particulate standard, there have also been proposals to lower NOx levels. Air-to-air aftercooling gives the coldest intake temperatures, which brings the NOx down.

It's a tricky battle, because as exhaust NOx is reduced, PM rises. If catalysts are indeed needed for '94, exhausts might have to run hotter, not cooler, during trap regeneration. Aftercooler bypass systems, like the one now being used by Volvo to avoid overcooling and to cut white smoke at idle, might be another solution.

Two-Stroke Survival

Detroit Diesel's long-lived two-stroke range has evolved into a niche-market powerplant. It now utilizes the same electronic unit injector as the company's four-stroke Series 60, giving much improved HC and low-smoke emissions. Optional is DDC's DDEC electronic control package.

Can these refinements carry the strokers through '94? Yes, says Dave Merrion, if they can meet the transit bus emission standards for '91—which are the same as the '94 truck regs.

"Our thrust with the two-stroke is three-pronged: methanol fuel program; compressed natural gas (CNG) program (versions of which are now running on the test bench); and the particulate trap program," explains Merrion. The trap project, a venture with Donaldson Co., is being conducted on 400 New York City buses powered by 6V-92s and 6-71s.

Still, sales of urban bus diesels may dry up from '91 through '93, as the only current feasible alternative to aftertreatment is methanol, CNG or liquified petroleum gas (LPG). All of these come with their own attendant problems.

New Turbocharger Tech

Variable-geometry turbochargers, still in their infancy in automobiles, are also being introduced to big diesels to help meet the '94 crunch. Some, including Mack and Detroit Diesel, will feature these units before '94.

The advantage of these turbos is improved boost control. Connected to an electronic control unit, boost management is even more precise over a greater rpm range, reducing emissions while increasing throttle response, horsepower, torque and fuel economy. Schwitzer's new Variable Power Turbine (VPT), and Garrett's just-announced VNT45, feature movable vanes which change exhaust angle around the turbine. Both are also designed for electronic control.

The Garrett VNT45 is now in production on Nissan's 290-350-hp diesels sold in other markets.■

Paul Richards of Chilton's Commercial Carrier Journal magazine contributed to this article.